THE PNEUMOOXYHEMOGRAPH-3, AN INSTRUMENT FOR THE INVESTIGATION OF THE FUNCTIONAL STATE OF BLOOD CIRCULATION AND RESPIRATION

A. M. Sviridov

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16. Abstract

The author has devised an instrument which can simultaneously or continuously record on paper tape a pneumogram, oxyhemogram and electrocardiogram with an indication of time. Simple changes in speed make it possible to record the frequency and rhythm of heart contractions. Such information is vital in treating cardiopulmonary conditions. The device can be used almost anywhere.

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A. M. Sviridov[1]

The device produced by us permits graphic recording of the physiological /50*
interdependence of respiration and blood circulation, to be recorded objectively and precisely as they occur. In the device we use a three-channel standard N-327-3 recorder, an electronic adapter, and pickups. A block diagram of the device is given in Figure 1. Electrical signals from the sensors are amplified in the electronic adapter to the levels necessary for the normal operation of the N-327-3 recorder. In the adapter units are mounted which supply the pickups /51
with power as are the tuning instruments and the controls for the operation of the entire device.

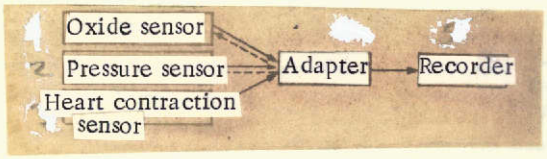

Figure 1. Block Diagram of the "Pneumooxyhemograph-3" Device.

The N-327-3 recorder adapter consists structurally of a metallic body provided with a relay switch. Figure 2 shows the outside view of the device.

Figure 3 shows the electrical diagram of the N-327-3 recorder adapter.

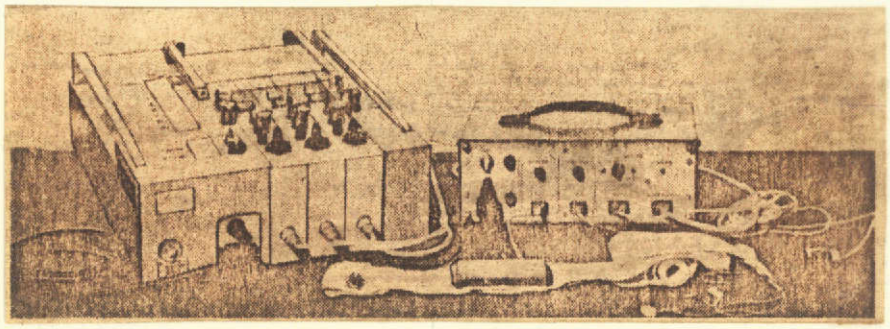

Figure 2. Outside View of the Device. Left, recorder; right, adapter; sensors visible in the foreground.

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[1]Military Academy of Chemical Defense, Moscow.
*Numbers in the margin indicate pagination in the foreign text.

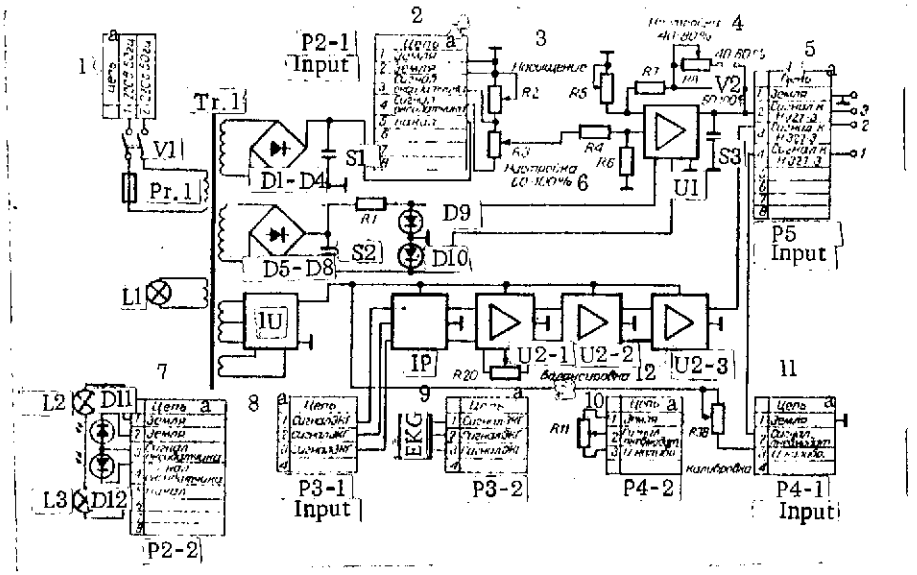

Figure 3. Electrical Diagram of the Sensors and Adapter for the N-327-3 Recorder. R1, MLT-2-5, 1 k; R2, SNO-0.5-33 k; R3, SNO--0.5-1.5 k; R4, MLT-0.125-30 k; R5, SP5-2-10 k; R6, MLT-0.125--6.8 k; R7, MLT-0.125-750 k; R8, SNO-0.5-4.7 Mom; R11 rheochord, 200 om; R20, SNO-0.5-470 om; R38, SNO-1-10 k; S1, K50-3-25-30; S2, K50-36-100-100; S3, K50-6-13-500; L1, SM-37; D1, D8, D226; D9, D10, KS156A; D11, FKDZ; D12, FKD1; 1U, dc voltage stabilizer: Ya5-3A; U1, dc amplifier, micro-design UT 402B; U2-1, U2-2, U2-3, transistorized differential symmetrical amplifiers; IP, source repeater on the field transistors; Tr.1, transformer; V1, V2, switch PV2-1; PR1, fuse PM1; P2-1, P5, rosette RGi-N-1-3; P2-2, plug RSh2N-1-17; P3-2, P4-1, rosette RG1N-1-1; P3-2, P4-2, plug RSh2N-1-5.

Key: 1: a, Circuit; 1, 220 V 50 Hz; 2, 220 V 50 Hz; 2: a, circuit; 1, ground; 2, ground; 3, oxide sensor signal; 4, oxide sensor signal; 5, incandescence; 3: saturation; 4: tuning; 5: a, circuit; 1, ground; 2, signal to N327-3; 3, signal to N327-3; 4, signal to N327-3; 6: tuning; 7: a, circuit; 1, ground; 2, ground; 3, oxide sensor signal; 4, oxide sensor signal; 5, incandescence; 8: a, circuit; 1, EKG signal; 2, EKG signal; 3, EKG signal; 9: a, circuit; 1, EKG signal; 2, EKG signal; 3, EKG signal; 10: a, circuit, 1, ground; 2, pneumo-sensor signal; 3, calibrator; 11: a, circuit; 1, ground; 2, pneumo-sensor signal; 3, calibrator; 12: balance.

The flow of the signal carrying data about saturation of the blood with oxygen passes from the oxide sensor to the P2-1 "Vhod" terminal (see Figure 3) located on the front panel of the adapter in the "oxyhemogram" sector. Then transmission continues to the R2 and R3 variable resistors used to stress the oxide pickup. The axis of the R2 resistor is visible on the front panel

with the inscription "Saturation" and the R3 resistor axis on the panel with "Adjustment 60-100%". Calibration of the oxyhemogram was achieved through the use of these resistors. The "saturation" resistor establishes the necessary signal level, and the "Adjustment 60-100%" resistor establishes compensation for the blood volume using the 60-100% scale, which corresponds to the position of the D2 toggle switch on the front panel of the 60-100% adapter. The signal /52 from the R6 resistor travels to a direct current amplifier. An amplifier for an integral microcircuit 1UT401B is used as the direct current amplifier. A variable R5 resistor provides amplifier balance. The amplifier is given negative feedback by the R7 resistor when working in the 60-100% scale (B2 toggle switch in position 60-100%) and when working on the 40-80% scale (B2 toggle switch in 40-80% position) by the R7 resistor and the variable R8 resistor (see Figure 3), the axis of which is visible on the front panel of the adapter with the description "Saturation 40-80%". By changing the feedback strength with the R8, we obtain the necessary coefficient of amplification in the amplifier when working on the 40-80% scale. From the amplifier a signal moves to juncture P5 (see Figure 3) and then through a connecting cable and a juncture from number 2 to the recorder input.

The biopotential amplifier (for the electrocardiogram record) consists of three differential symmetrical amplifiers with intensive feedback, which acts only for a cophasal signal. Therefore the static of commercial frequency found with electrodes connected to a person is comparatively well suppressed, and the usable signal is reinforced. A variable R20 resistor (see Figure 3), the axis of which is visible below the switch on the front panel under the inscription "Balance", is introduced to balance the first cascade. Source repeaters for field transistors are used to coordinate the amplifier, which has a large initial resistance (on the order of 0.5 meghoms), with the biopotential source. The amplifier coefficient is 1,000.

The current units produce the following voltages (see Figure 3): 12-volt direct stabilized current to feed the amplifier of the biopotentials and the pressure sensor, as a source of 12-volt current, a unified supply terminal IV of the Ya5-3A type is used with a Tr.1 transistor, 12-volt direct stabilized current for the 1UT402B microcircuit power, a rectifier mounted on D226V diodes

across bridge circuit (D5-D8), stabilization of current is achieved by stabilizers KS156A (D9-D10); 6-volt direct stabilized current for feeding the illuminating bulbs of the oxide sensor, a rectifier mounted on D226B diodes across a bridge circuit (D1-D4).

The S1 and S2 condensers are used to filter the variable component, and the variable 24-volt current feed the L1 signal lamp (see Figure 3).

On the front panel of the recorder adapter one sees the following supply block elements: the P1 network junction, the "circuit" V1 toggle switch, the PR1 fuse, and the L1 signal lamp.

The device, the principal of operation of the N-327-3 recorder, and its concomitant sequence of operations are explained in the technical description and in the instructions for use which are attached to the recorder. The N-327-3 recorder has a tape take-up speed of from 1 to 250 mm/min which changes gradually. The recorder unit has a time marker with a marked frequency of F = 1 Hz.

We have also worked out a new variation of pressure sensor which works on the resistor principle (Figure 4). It is a device intended to transform variations of the perimeter of the thoracic cage in breathing into an electrical signal, allowing graphic recording of the frequency, depth, and delay in respiration.

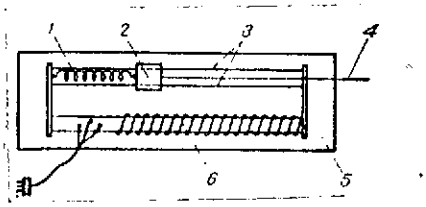

Figure 4. Diagram of the Resistor Pressure Sensor. 1, Spring; 2, moveable contact; 3, guide; 4, wire; 5, getinax plate; 6, rheochord.

On the getinax plate 5, is a reinforced Rheochord 6, along which the moveable contact 2, returned to its original position by the spring, 1, is displaced under the influence of the stretching force of the wire 4. The moveable contact slides along guide 3 and has a position indicator. The pickup is provided with a cover made of frosted, organic glass on which there is a transparent strip with fixed grooves. The position of the moveable contact is controlled according to the indicator through the transparent strip. The pickup is reinforced at the bridge. The bridge consists of two halves united by a rubber band. The pickup is attached to the

bridge in the places where the bridge is connected with the rubber band in such a way that the foundation of the pickup if fastened to one end of the bridge, and the moveable wire to the other. During respiration, the thoracic volume and the length of the bridge vary. The length on the bridge is changed on account of the expansion of the rubber, and this expanding force is applied to the wire and brings the moveable contact into motion. The pressure taken from the reel cord by the moveable contact is directly proportional to the changes in the thoracic volume and reflects the picture of the respiratory processes of the subject. The electrical diagram of the rheochord connection is shown in Figure 3. The 12-volt direct current is transmitted to the rheochord by means of a variable R38 resistor. When the R38 resistance changes, the current flowing through the rheochord changes and consequently the sensitivity of the sensor changes. The axis of the R38 resistor can be seen on the front panel with the inscription "Calibrator."

This instrument provides the possibility of recording on paper tape a pneumogram, an oxyhemogram, an electrocardiogram (or the frequency and rhythm of heart contractions, depending on the speed of the tape's movement) and a time marker, simultaneously and continuously.[2]

The instrument permits simultaneous study and association of various /53
indicators of blood circulation and respiration: (a) the frequency and intensity of respiration, the nature of inhalation and exhalation, the duration of respiration delay in inhalation and exhalation; (b) the degree of oxygen saturation in the blood as it occurs; (c) the nature of the oxyhemographic curve in respiration delay; (d) the velocity of blood flow; (e) the frequency and rhythm of heart contractions; (f) electrocardiogram. It also permits investigation of hemodynamics by dye distribution methods.

Figure 5 shows a fragment of a tape with its recording.

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[2]In choosing the set of parameters for synchronous recording, it is necessary to consider not only their physiological relationship, but also the rate of the pertinent processes. An oxyhemogram varies a great deal more slowly than an electrocardiogram.

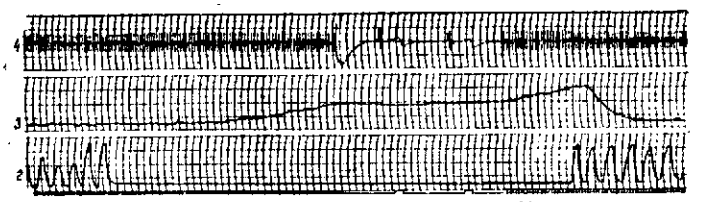

Figure 5. Fragment of a Tape with Recording of a Pneumogram (2), Oxyhemogram (3), an Electrocardiogram (4); 1, Time Marker.

The device can be used in examining patients at home, under polyclinical and field conditions, in hospitals, clinics and scientific research institutions for diagnostic purposes, dynamic observation, checking the acceptability of physical loads and of administered treatment, for the purpose of studying hypoxia conditions and hypervaric oxygenation, and of solving specialized questions about the conditions of health and medical rehabilitation of patients with cardiopulmonary pathologies.

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